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The Genus *Mymaromella* (Hymenoptera: Mymarommatidae) in North America, with a Key to Described Extant Species

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Abstract.—A key is given to the five described extant species of *Mymaromella*. Two new species, *Mymaromella pala* Huber & Gibson, sp. n. and *M. palella* Huber & Gibson, sp. n. (Mymarommatoidea: Mymarommatidae), are described as the first species of the family from North America. Psocoptera (Insecta) are proposed as the probable hosts of Mymarommatidae, based on circumstantial evidence obtained from their morphology, phenology, biogeography, habitats, and paleontology.

Gibson et al. (2007) revised the higher classification of Mymarommatoidea (Hymenoptera), recognizing two families, the extinct family Gallorommatidae and the Mymarommatidae. Mymarommatidae contains 18 described species in five genera, of which two genera and seven species are known only from fossils (Gibson et al. 2007). One of the three extant genera, *Mymaromella* Girault, contains one extinct and three extant species. The extant species include the type species of the genus from Australia, *M. mira* (Girault), plus *M. chaoi* (Lin) from China and *M. cyclopterus* (Fidalgo & De Santis) from Argentina. The extinct species *M. duerrenfeldi* (Schlüter & Kohring), from Sicilian amber, is about 5 million years old.

No extant species of Mymarommatidae have been formally described from the Nearctic region though their presence has been known for many years (Clouâtre et al. 1989, Gibson 1993, Gibson et al. 2007). The three specimens that Clouâtre et al. (1989) identified in their paper as an unidentified species of *Palaeomymar* Meunier represent one of our new species of *Mymaromella*. Since their initial collection, several more specimens of this species and a second new species of *Mymaromella* have been collected from various localities in Canada and USA. Recent, intensive surveys in Michigan for natural enemies of the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) yielded about 30 specimens of one of the new species. These specimens emerged in the laboratory from cut sections of ash trees (*Fraxinus* spp.: Oleaceae). Here we describe the two *Mymaromella* species from North America and provide a key to the five described extant species of *Mymaromella*. Undescribed species tenta-

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tively identified by Gibson et al. (2007: 120, species 16–23) are not described here because of insufficient material.

Gibson (1993) reported a single specimen of one of our new species as reared from a backet fungus. Other than this record and the specimens reared from ash logs, nothing is known of the biology or hosts of Mymarommatidae. Because of their minute body size, Yoshimoto (1984) suggested mymarommatids probably are parasitoids of insect eggs.

METHODS

This study is based on specimens from the institutions listed below. Acronyms preceding the institution designate deposition of specimens; the name of the curator of the collection is given in parentheses:

ANIC Australian National Insect Collection, Canberra, Australia (J. LaSalle).

CNC Canadian National Collection of Insects, Ottawa, Canada (G. Gibson, J. Huber).

FAFU Biological Control Research Institute, Fujian Agricultural and Forestry University, Fuzhou, Fujian, China (N.-Q. Lin).

MLPA Museo de la Plata, La Plata, Argentina (M. Loiácono).

MSUC Entomology Collection, Michigan State University, East Lansing (G. Parsons).

UCRC University of California, Riverside, CA, USA (S. Triapitsyn).

USNM National Museum of Natural History, Washington, DC, USA (M. Gates).

Numerous specimens of *M. pala* n. sp. were obtained during research on the natural enemies of the emerald ash borer in southeastern, lower Michigan, USA (Bauer et al. 2003, 2007). The specimens were reared from heavily infested green (*Fraxinus pennsylvanica* Marsh) and white (*F. americana* L.) ash trees. At each of 14 sites, 2 or 3 heavily infested ash trees were randomly selected, felled with a chainsaw, and cut into 60 cm logs from March through May 2004; each log was identified by site, tree, and height above the ground. The logs were stored in a walk-in cold room at 4°C. From April through November, logs were removed from cold storage and placed inside individual cardboard tubes (20–30 cm in diameter by 70 cm in length) (Saginaw Paper Tube, Saginaw, MI) for emergence of insects in the laboratory at 20–25°C, 40–60% RH, and 24 hr lighting. The emergence tubes were capped on one end with a plastic lid to exclude light and the other end was sealed with a plastic lid modified by the addition of a translucent plastic screw-top collection cup from which emergent insects were collected daily for up to 8 weeks. The mymarommatid specimens, already dead in the collection cups as well as at the bottom of the emergence tubes, were removed and placed in 70% ethanol for subsequent preparation at the CNC. Some specimens were slide mounted in Canada balsam and the rest were card-mounted. A few specimens had been used previously for scanning electron micrographs (Gibson et al. 2007).

Material examined includes figure number(s) for the specimens that were used to illustrate the respective species in the plates of illustrations. Measurements used in the species treatments are in micrometers. Morphological terms are described in Gibson (1997). Abbreviations used are FIT = flight intercept trap, fl_x = funicle segment (female) or flagellomere (male), FWL = fore wing length, FWW = fore wing width, MT = Malaise trap, POD = posterior ocellus diameter, POL = poserior ocellar line.

MYMAROMELLA GIRAULT

Mymaromella Girault, 1931: 4; Gibson et al., 2007:100 (redescription).

Diagnosis.—Propleura abutting but not fused; foretibial calcar relatively long,

curved and apically bifurcate; occipital plate with paramedian setae (apomorphy 4); clava of female with the two or three s4-type sensilla usually situated more or less medially (apomorphy 13) but sometimes in dorsal third; metanotum fused posterolaterally to propodeum (apomorphy 16); metapleural pit about midway between ventral margin of pleuron and propodeal spiracle (apomorphy 18).

The above features and apomorphy numbers are abstracted from the key and character state summary in Gibson et al. (2007: 94, 120). The genus is variable and difficult to define but the curved, apically bifurcate calcar separates *Mymaromella* species from those of *Palaeomymar* and *Mymaromma*. In females, the 1-segmented clava separates *Mymaromella* species from those of *Zealaromma*.

KEY TO FEMALES OF EXTANT SPECIES OF *MYMAROMELLA*

1	Ocelli absent (Figs 13, 14); fore wing convex, spoon-like	... ***M. palella* Huber & Gibson**
–	Ocelli present (Figs 1, 2); fore wing flat	... 2
2(1)	Fore wing without a single, long, thin seta on hind margin just basal to row of short spine-like setae (Figs 17, 19, 20, 21), the posterior fringe thus beginning with a short, spine-like seta	... 3
–	Fore wing with a single long, thin seta basally on hind margin, the posterior fringe thus beginning with a long, slender seta (Figs 18, 22, 23)	... 5
3(2)	Fore wing wider and more distinctly truncate apically (Fig. 19)	... ***M. cyclopterus* Fidalgo & De Santis**
–	Fore wing narrower and more rounded apically (Figs 17, 18, 20)	... 4
4(3)	Fore wing surface with acanthae shorter and thinner (Fig. 20)	... ***M. pala* Huber & Gibson**
–	Fore wing surface with acanthae longer and thicker (Figs 17, 18)	... ***M. chaoi* Lin (part)**
5(2)	Eye with more than 35 ommatidia	... ***M. mira* Girault**
	Eye with fewer than 20 ommatidia (specimens from Hebei, China, with unusually long ovipositor)	... ***M. ?chaoi* Lin (part)**

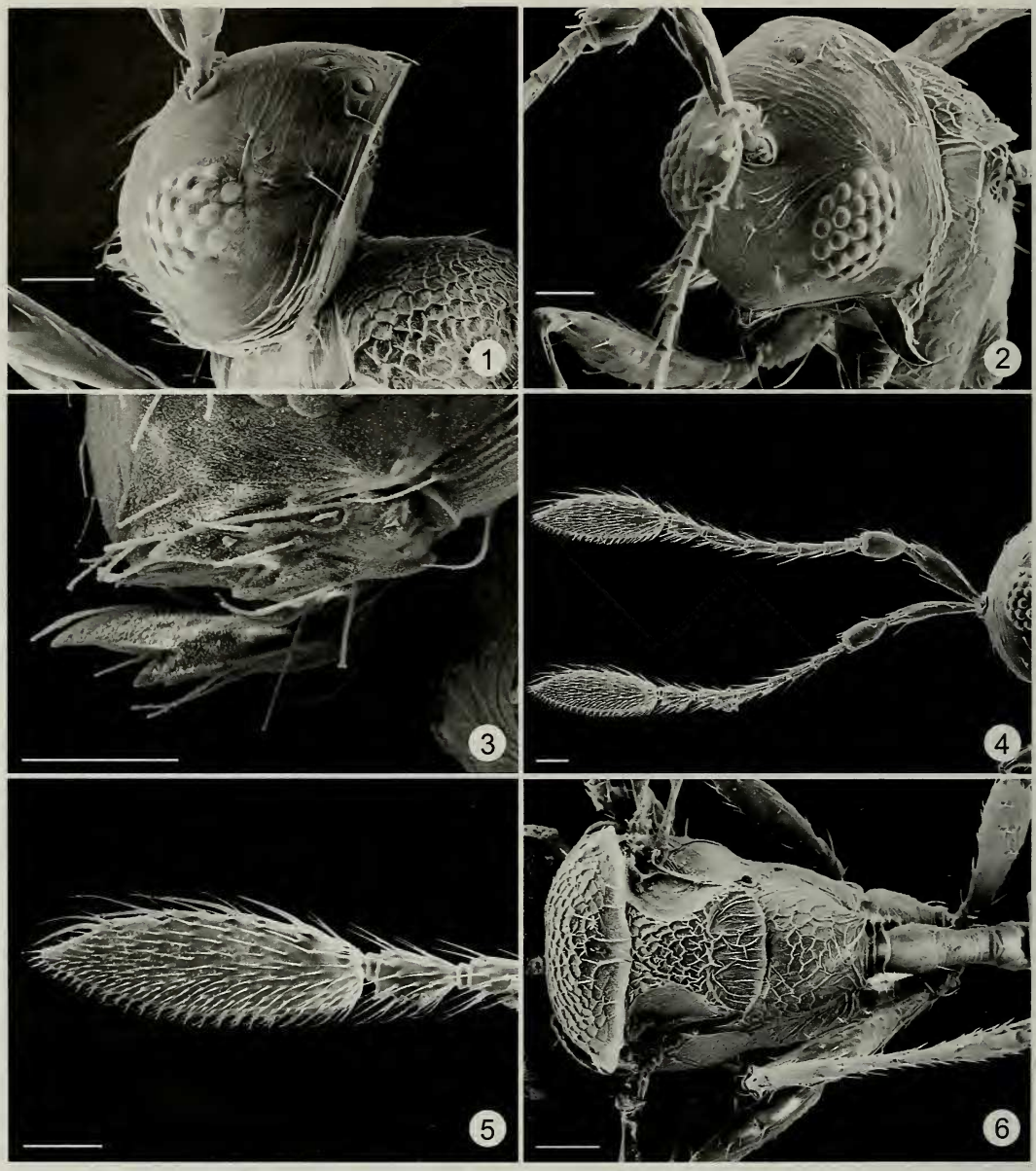
***Mymaromella pala* Huber & Gibson, sp. n.**
(Figs 1–10, 20, 26, 30)

Mymaromella sp. 14: Gibson et al., 2007 (figs 41, 44, 48, 91, 92, 117, 130, 139, 167, 177, 178).

Etymology.—The specific epithet *pala* is Latin for "shovel", referring to the shovel-shaped outline of the fore wing.

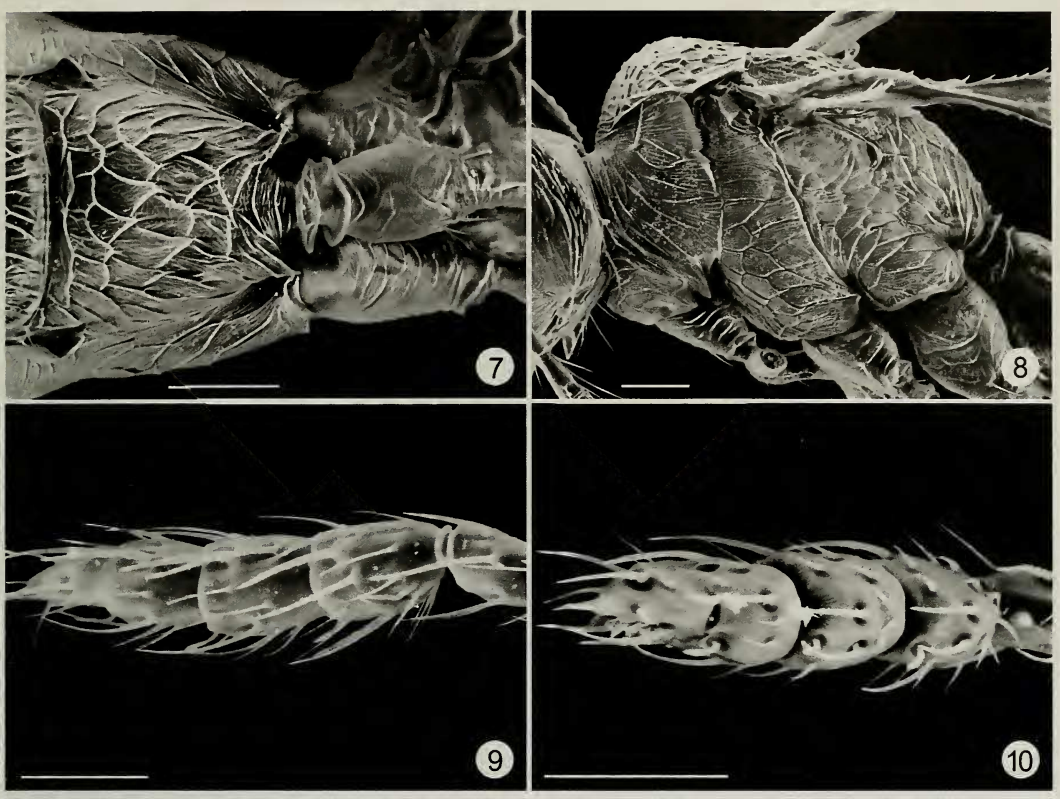
Material examined.—**Holotype** female (CNC), in good condition, mounted dorsally under three cover slips on slide with two labels: 1. "USA: MI, Wayne Co., Flat Rock, Oakwoods Metro Park, em. 14.ix.2004 ex log of Fraxinus pennsylvanicus or americana". 2. "Mymaromella pala Huber and Gibson Holotype ♀ dorsal". 3. "CNCI JDR-specm 2005-387 (green label)".

Paratypes. 37♀ and 1♂ on cards or points, 7♀ and 2♂ on slides. **CANADA. Ontario:** Haliburton Forest and Wildlife Reserve, 45°15'N 78°35'W, 7.viii.2001, C. Vance, canopy MT, maple (Fig. 6) (3♀, CNC), same data, ground MT, pine forest (1♀, CNC); Oxford Mills, 3–10.viii.1973, G. Gibson (1♀, CNC); Shirley's Bay, Innes Point [ca. 15 km W. Ottawa], 29.vii–5.viii, 5–12.viii, 5–11.ix (Figs 1, 4, 5), 24.ix–1.x.1985, M. Sanborne, MT (4♀, CNC).**USA. California:** *Plumas Co.*, 8 mi. NW. Chester, Warner Creek, 5000', 3.ix.1993, E.E. Lindquist, ex. cottonwood litter (2♀, CNC). **Maryland:** *Calvert Co.*, 7 mi. S. Prince Frederick, 24.viii–14.ix.1987, hardwood forest, MT, CNC Hym. team (1♀, CNC). *Prince George Co.*, Laurel, Patuxent Wildlife Research Center, 25.vii–8.viii.1980, M. Schauff, Malaise in old field (1♂, USNM).



Figs 1–6. *Mymaromella pala*. 1, head, dorsolateral; 2, head; 3, mandibles; 4, female antennae; 5, female clava; 6, mesosoma and petiole, dorsal. Scale lines = 20 μm.

Michigan: *Livingston Co.*, Brighton Island Lake State Park, 2.vi.2004 (1♀, CNC). *Oakland Co.*, Milford, Kensington Metro Park, em. 30.viii and 10.xi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (4♀, UCRC, USNM) and 25.v.2004 (Figs 9, 10) (1♂, CNC); White Lake, Indian Springs Metro Park, 22.v and 17.vi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (2♀, MSUC). *Washtenaw Co.*, Ann Arbor, Delhi Metro Park, em. 22.v and 4.vii.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (4♀, MSUC, USNM); Willis, Sylvia Taylor's woodlot, em. 26.vi.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (1♀, CNC). *Wayne Co.*, Belleville, Lower Huron Metro Park, em. 24.v.2004, ex mixed rearing logs, L. Bauer (4♀, CNC, FAFU) and 18.viii.2004,

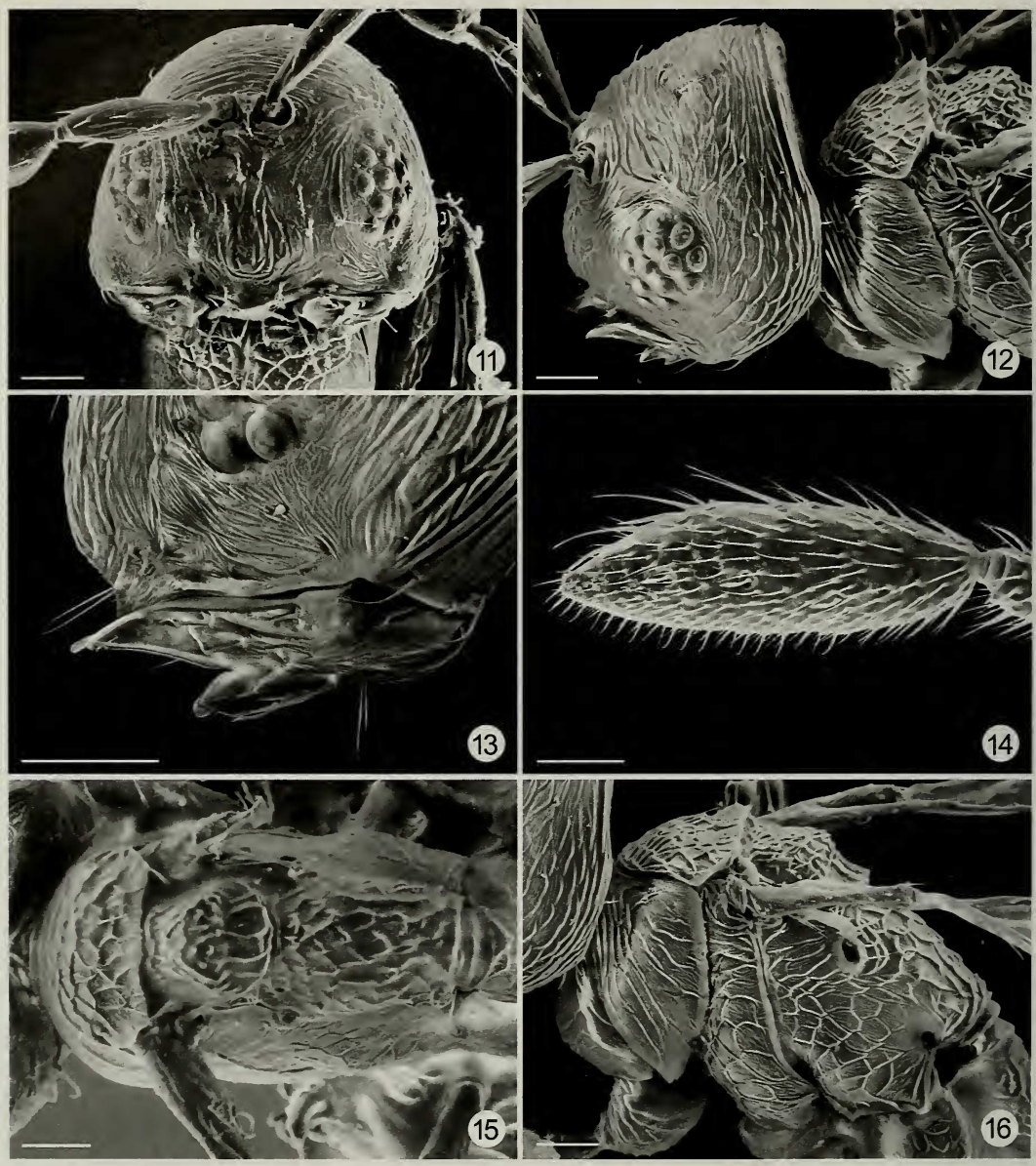


Figs 7–10. *Mymaromella pala*. 7, propodeum and petiole, dorsal; 8, mesosoma, lateral; 9, male clava, lateral; 10, male clava, anterolateral. Scale lines = 20 μm.

ex. *Fraxinus pennsylvanica* or *F. americana* logs (Fig. 30) (1♀, CNC); Flat Rock, Oakwoods Metro Park, em.10.vi (Fig. 3), 11.vi, 18.viii and 14.ix.2004, ex *Fraxinus pennsylvanica* or *F. americana* logs (3♀, 1♂, CNC); various counties in Detroit area, em. 2.vi (Fig. 2), 8–9.vi and 19.vi.2004, ex white or green ash logs (4♀, CNC). **New York:** *Jefferson Co.*, Alexandria Bay environs, 7.v.1978, L. Masner and L. Huggert, reared in lab. from dry bracket fungus on ?*Acer* sp. v–vi.1978 (1♀, CNC). **North Carolina:** *Dorchester Co.*, Francis Beidler Forest, 10 km NE. Harleyville, 5–15.v.1987, bald cypress swamp, MT (1♀, CNC). *McDowell Co.*, 37°00'N 81°30'W, 9.vii–17.ix.1987, FIT, oak-rhododendron CNC Hym. team (2♀, CNC). **South Carolina:** *Anderson Co.*, Pendleton, Tanglewood Spring, 34°38.7'N 82°47.1'W, 225 m, 16–29.vii.1987, J. Morse, MT (Figs 7, 8) (3♀, CNC). **Virginia:** *Montgomery Co.*, 8 km NW. Blacksburg, 19–30.vi.1987, 1000 m, rural area, MT, CNC Hym. team (1♀, CNC).

Diagnosis.—Mymaromella pala differs from *M. palella* Huber & Gibson, the only other *Mymaromella* species in North America, by the presence of ocelli, and a flat fore wing with longer and more numerous marginal setae (Fig. 20). *M. palella* has a concave fore wing with shorter, thicker and fewer marginal setae, Fig. 21, fewer eye facets (cf. Figs 2, 11) and a comparatively wider gena.

Mymaromella pala differs from *M. cyclopterus* (Fidalgo & Ogloblin) by its slenderer fore wing with less prominent acanthae on the wing surface, and from *M. mira* Girault and some *M. chaoi* Lin by the absence of a long, basal seta on the posterior margin of the fore wing. From other *M. chaoi* sensu Lin (1994) that have a long seta on the



Figs 11–16. *Mymaromella palella*. 11, head, anterior; 12, head + anterior part of mesosoma, dorsolateral; 13, mandible; 14, female clava; 15, mesosomal, dorsal; 16, mesosoma, lateral (= fig. 96 in Gibson et al. 2007). Scale lines = 20 µm.

posterior margin of the fore wing it is differentiated by shorter and thinner acanthae on the wing surface (cf. Figs 18, 20).

Description.—**Female**. Body length 297–356 µm (mean = 328, n = 9; air dried specimens from Michigan). Body honey yellow, except clava and sometimes apical two funicular segments slightly darker, greyish, and apical half of gaster brown. Petiolar segments and legs pale yellow. Eyes and ocelli grey with a pink tinge. Hind leg and, less distinctly, middle and fore legs with apparent apex of each tarsomere narrowly brown (slide mounts show that it is the basal insertion of a

segment into the previous segment that is brown). Mesopleuron occasionally with minute brown spot below base of fore wing.

Head. Width 102–108 (n = 5). Face with 1 seta ventromedially next to each eye, 2 or 3 submedian setae in a row ventral to each torulus, 2 median setae in a line ventral to and between toruli and 4 short submedian setae in a row just above mouth opening; sculpture finely obliquely striate and oblique between eyes except medially where it forms a faint, circular, engraved-reticulate pattern (Gibson et al. 2007, fig. 48). Ocelli present, forming an equilateral triangle (Figs 1, 2); POL = 11, POD = 6. Frons with 1 seta next to anterior ocellus and 2 setae lateral to posterior ocelli; sculpture transverse-striate. Eye with about 20–26 ommatidia. Back of head (Gibson et al. 2007, fig. 41) with 2 submedian setae well above foramen magnum and 3 setae in a vertical row lateral to foramen; sculpture above foramen magnum reticulate, isodiametric medially but becoming more elongate laterally; sculpture lateral to foramen magnum engraved and obliquely striate; gena width equal to eye width. Mouthparts as shown in Gibson et al. 2007 (fig. 41, posterior view; fig. 44, ventral view); mandible with two distinct teeth (Fig. 3).

Antenna. Fl_6 the longest funicular segment (Figs 4, 26), fl_7 the widest, with its ventral margin convex (Gibson et al. 2007, fig. 178 nec 177), clava in lateral view as in Fig. 5. L(W) measurements (n = 6, except n = 4 for scape): scape 59–63 (12–15); pedicel 32–34 (14–16); fl_1 10–13 (6–7), fl_2 13–15 (6–7), fl_3 15–17 (6–7), fl_4 15–18 (7), fl_5 18–23 (7–8), fl_6 27–29 (7–9), fl_7 23–26 (11–12), clava 78–85 (20–27).

Mesosoma. Total length 128–138 (n = 7). Mesoscutum length 36–41, width 82–84 (n = 4); scutellum length 43–48. Sculpture dorsally (Fig. 6) mostly isodiametric reticulate on mesoscutum except posteriorly, on anterior scutellum and, more coarsely, on propodeum (Fig. 7; Gibson et al. 2007, fig. 91); axilla smooth; posterior margin of mesoscutum and posterior scutellum with elongate reticulate sculpture (Fig. 6); mesosoma laterally (Fig. 8) with shallower, almost engraved reticulation. Propleura, pronotum, and mesopleuron faintly, striate/reticulate (Fig. 8).

Fore wing. Flat, with broadly rounded apex (Fig. 20; Gibson et al. 2007, figs 117, 130, 167); dorsal surface with relatively short acanthae arranged in poorly defined rows at least in basal part of blade; posterior margin with about 8 short, spine-like setae. FWL 317–365, FWW 120–148, FWL/W 2.27–2.87, longest marginal setae 121–151, venation length 59–68 (n = 8).

Legs. Metacoxa reticulate, remainder of legs apparently smooth. Metatibia length 104–110 (n = 5).

Metasoma. Petiolar segment 1 length 72–78, segment 2 length 69–72 (n = 7), both petiolar segments with irregular transverse striations and segment 1 with two setae at or just before mid-length (Gibson et al. 2007, fig. 92). Gaster apparently smooth. Ovipositor (including valves) length 49–53 (n = 5), 0.36–0.40 (n = 6) times metatibia length.

Male. Similar to female except as follows. Antenna (Fig. 30; Gibson et al. 2007, fig. 177 nec fig. 178) with 4-segmented clava, but apical two segments only indistinctly separated (Figs 9, 10). L/W measurements (n = 1) scape about 57 (12), pedicel 33 (17), fl_1 11 (7), fl_2 15 (8), fl_3 16 (7), fl_4 17 (7), fl_5 21 (8), fl_6 27 (8), fl_7 26 (12), fl_8 25 (16), fl_9 22 (16), fl_{10} 17 (15), fl_{11} 20 (12). POD 9, slightly larger than for female, and POL 9, slightly shorter than for female.

Biology.—Unknown. Specimens were reared from a bracket fungus and from ash logs (see type material, above). Based on its morphology (flat, well-developed fore wing evidently capable of flight) and micro-habitat (ash logs), *M. pala* is postulated to parasitize arboreal hosts on tree trunks.

Mymaromella palella Huber & Gibson, sp. n.

(Figs 11–16, 21, 27)

Palaeomymar sp.: Clouâtre et al., 1989: 825 (collection localities, habitat description).
Mymaromella sp. 15: Gibson et al., 2007 (figs 43, 96) (generic transfer).

Etymology.—The specific epithet *palella* is Latin for "little shovel", referring to the shovel-like nature of the fore wing, both in outline and in depth.

Material examined.—**Holotype** female (CNC), in good condition, mounted dorsally under two coverslips on slide with three labels: 1. "Canada: QC, Mirabel, 15.viii.1984, A. Clouâtre, forest litter, CNC det. lot 88-638". 2. "CNCI JDR-specm 2005-207 (green label)". 3. "Mymaromella palella Huber & Gibson HOLOTYPE female dorsal".

Paratypes. 5♀. **CANADA. New Brunswick:** Kouchibouguac Nat. Park, Kolloch Creek trail, 10.viii.1979, E. Lindquist, ex. maple, white pine litter, Berlese extraction (Figs 12, 13, 16) (1♀, CNC). **Ontario:** Alfred Bog, 2.vii.1984, M. Sanborne, MT (Fig. 11) (1♀, CNC); 42 mi. N. Hurkett, 2 mi. S. of outlet at Black Sturgeon Lake, 17.viii.1972, E.E. Lindquist, ex. mixed cedar-alder litter (1♀, CNC). **Quebec:** Mirabel, 25.vi.1984, A. Clouâtre, forest litter (Fig. 15) (1♀, CNC); Argenteuil Co., 7 km NE. Grenville, 45 30'41"N 74 34'34"W, 115 m, ex. Berlese extraction of soil from maple-hickory forest, A. Clouâtre (Fig. 14) (1♀, CNC).

Diagnosis.—*Mymaromella palella* differs from *M. pala* and all other described *Mymaromella* by the absence of ocelli (Fig. 12). It is also differentiated from *M. pala* by its convex fore wing with thicker and fewer long marginal setae (cf. Figs 20, 21), fewer eye facets (cf. Figs 11, 12) and comparatively wider gena. The body of *M. palella* is longer than that of *M. pala*, but this may partly be an artifact due to different methods of preparation (critical point drying vs air drying).

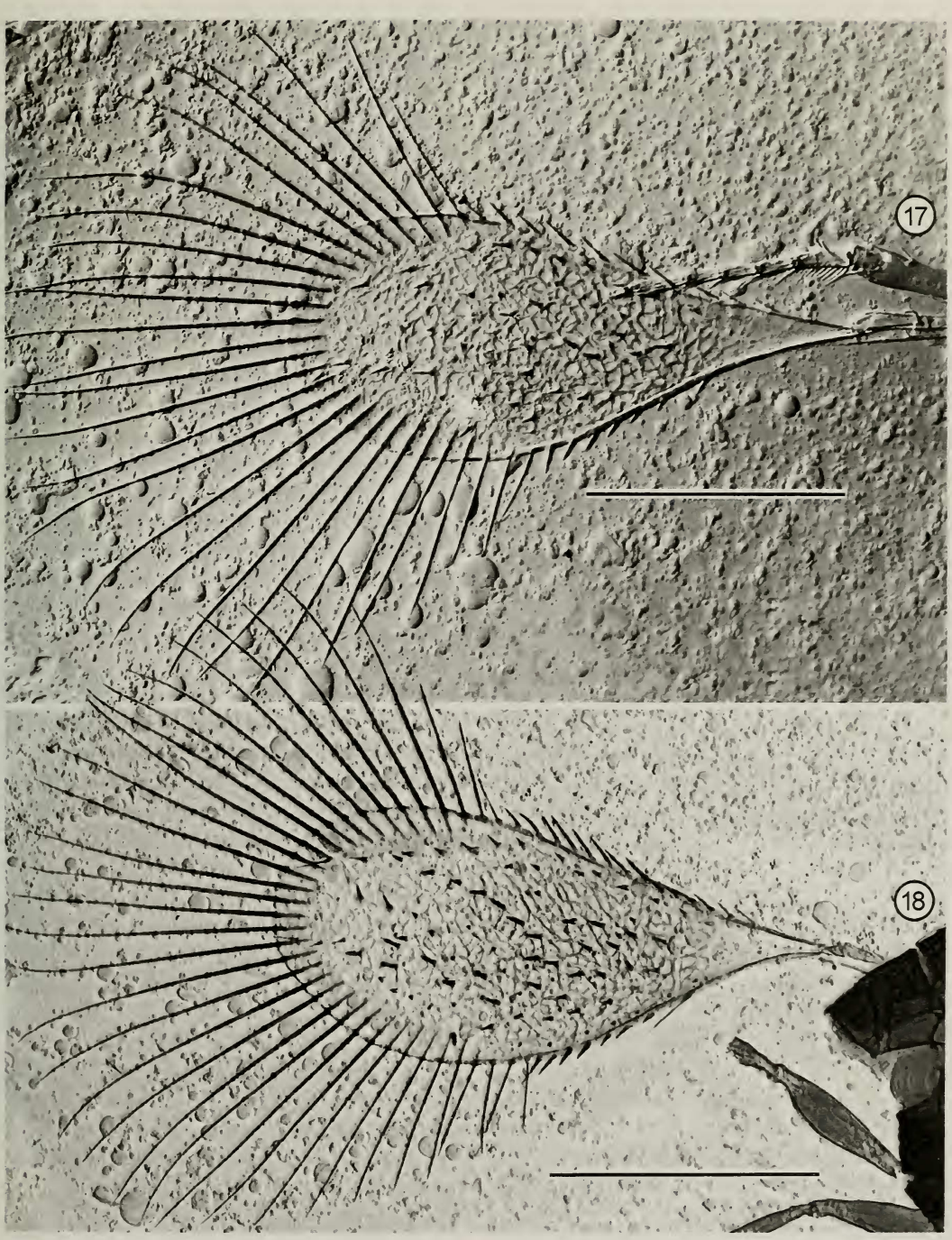
Description.—**Female.** Body length 425–455 μm (mean = 444, n = 5, critical point dried paratypes). Body honey yellow except gaster entirely or, sometimes, only apical third brown. Petiolar segments and legs yellow. Eyes grey with a pink tinge. Apparent apex of each tarsomere narrowly brown.

Head. Width 110–114 (n = 2). Face with 3 setae ventrolaterally next to each eye, 2 submedian setae in a horizontal row below toruli, and 4 short submedian setae in a row just above mouth opening (Fig. 11); sculpture finely obliquely striate between eyes except medially where it forms a circular, engraved-reticulate pattern. Ocelli absent (Figs 11, 12). Frons with a transverse row or two of 2–6 setae above eyes and toruli; sculpture transverse-striate. Eye with about 13 ommatidia (Figs 11, 12). Back of head with 2 submedian setae well above foramen magnum and 4 setae in a vertical row lateral to foramen; sculpture above and lateral to foramen magnum apparently elongate-reticulate to almost striate; gena width greater than eye width. Mouthparts (ventral view) as in Gibson et al. (2007, fig. 43); mandible with 2 distinct teeth (Fig. 15).

Antenna. Fl_6 the longest funicular segment (Fig. 27), fl_7 the widest, with its ventral margin convex, clava in lateral view as in Fig. 16. L(W) measurements (n = 2): scape 53–56 (15–16); pedicel 33–35 (17–19); fl_1 16–18 (8–9), fl_2 16–22 (8–9), fl_3 21–22 (8–9), fl_4 23–24 (9), fl_5 25–28 (8–9), fl_6 38–39 (10), fl_7 29–31 (10–13), clava 87–97 (22).

Mesosoma. Total length 488 (n = 1). Mesoscutum length 29, width about 45 (n = 1); dorsally with sculpture mostly isodiametric reticulate, except axilla smooth; scutellum relatively narrow, with sculpture finer anteriorly than posteriorly (Fig. 17), and laterally with shallower reticulation (Gibson et al. 2007, fig. 96).

Fore wing. Distinctly convex, spoon-shaped (Fig. 21, wing flattened by cover slip and hence slightly distorted), with about 18 long marginal setae at wing apex and distal quarter of blade beyond venation, but with short, spine-like setae along



Figs 17, 18.—*Mymaromella chaoi*, fore wings. 17, holotype; 18, paratype. Scale lines = 50 μm.

basal three-quarters of anterior and posterior margins beyond venation. Dorsal surface of wing with acanthae relatively long, thick and arranged in fairly distinct, oblique rows, at least in basal part of blade. FWL 314–335, FWW 130–134, FWL/W 2.42–2.65, longest marginal setae 79–84, venation length 52–59 (n = 2).

Legs. Metatibia length 143 (n = 1).

Metasoma. Petiolar segment 1 length 72, segment 2 length 40 (n = 1). Gaster smooth. Ovipositor (including valves) length 70–81 (n = 2), 0.49 (n = 1) times metatibia length.

Male. Unknown.

Biology.—Unknown. Based on its morphology (fore wing somewhat reduced and presumably partially protective in function) and microhabitat, *M. palella* is postulated to parasitize hosts in soil or litter. Clouâtre et al. (1989) obtained their specimens from Berlese extraction and the specimens collected by Linquist came from forest litter extractions. *Mymaromella palella* is the only described species of *Mymaromella* that is adapted to crawling through soil or litter as evidenced by the lack of ocelli, relatively few ommatidia in the eye, shortened, spoon-shaped (in depth as well as in outline) fore wing evidently able to envelop the dorsal half or so of the metasoma, and fore wing fringe with relatively few, somewhat thicker and shorter setae than typical. One of the specimens collected by Clouâtre et al. (1989) had only partially expanded wings, indicating that it had freshly emerged from a host.

Mymaromella chaoi Lin
(Figs 17, 18, 24)

Palaeomymar chaoi Lin, 1994: 123.
Mymaromella chaoi Gibson et al., 2007: 100 (generic transfer).

Material examined.—Holotype female (FAFU) on slide under one square cover slip, with three labels in Chinese and English (English part quoted here): 1. "Jinshan, Fuzhou, N26° E119°, 30 Oct. 1987, Naiquan Lin Yellowpan trap." 2. "Palaeomymar chaoi Lin (♀) Holotype". 3. "Holotype (red label)."

Paratypes (Fig 24) (14♀ in FAFU). Because the paper is in Chinese an English translation of localities is provided here. All paratypes, only 10 of which were seen, are from Fujian province as follows: same locality as holotype but 13.ix, 20.ix, 17.x (Fig. 18), 20.x, and 24.x.1987 (7♀); Anle, Ninghua, 16.x.1987 (1♀); Wenquan, Xianyou, 7.x.1987 (1♀); Youxi County, 10.viii.1987 (1♀). All were collected in yellow pan traps. Unfortunately, the specimens are mounted in cloudy balsam.

Six females of *M. chaoi* not listed in the original description (the label dates do not correspond with description dates), and which are therefore not part of the type series, were also examined. Four are from the holotype locality but collected 2.viii.1985, 29.xi.1987, 30.x.1987, and 3.i.1988. One is from Henan, Jiaozuo, 31.vii.2006; it has an ovipositor/hind tibia ratio of 0.42. Two, from Guangxi, Nanning, 30.x.2002 and from Hainan, Danzhou, 6.v.2002, each have an ovipositor/hind tibial ratio of 0.56. All three specimens are considered to be conspecific with *M. chaoi* because their ovipositor/hind tibia ratio falls within the range of the type series. They are the first specimens of *M. chaoi* collected outside Fujian province.

Descriptive notes.—**Female**. Measurements were taken from type specimens (holotype included) collected at the type locality only.

Body length. 378 μm (holotype).

Antenna. Fig. 24. L(W) (n = 10): scape 46–66 (12–18); pedicel 29–36 (15–20); fl_1 10–14 (6–8), fl_2 10–17 (6–8), fl_3 12–19 (6–8), fl_4 12–17 (6–8), fl_5 15–21 (7–9), fl_6 20–30 (7–10), fl_7 20–28 (11–15), clava 62–96 (24–33).

Fore wing. Figs 17, 18. FWL (n = 7) 270–360, FWW 92–134, FWL(W) 2.71–2.95. Based on wing length, *M. chaoi* is the smallest species among the described *Mymaromella* and has the narrowest wings among the species with flat wings.

Metasoma. Ovipositor very short, arising in the apical third of the gaster, 0.39–0.69 times hind tibial length (n = 8).

Variation.—The holotype and five paratypes of *M. chaoi* do not have a long basal fringe seta on the posterior margin of the wing whereas five other paratypes do have it. In specimens lacking the seta it is not

because it is broken off because either the long seta is present on both fore wings of the same specimen or it is absent from both fore wings. At present we cannot determine if this is individual variation or whether two sibling species are present. The species is keyed out twice in order to emphasise the presence or absence of this seta in specimens from the same locality.

Three specimens, not included in the type series, were examined from Hebei, Yangjiaping, viii.2005 (FAFU). They are labelled as *M. chaoi* but have relatively longer ovipositors: ovipositor/hind tibial ratio of 0.93–0.95 and the ovipositor clearly occupies a relatively longer proportion (0.61–0.77) of the gaster than in *M. chaoi*. They are probably not *M. chaoi*. The ovipositor/hind tibia length of the type series of *M. chaoi* varies by about 1.8 times (0.39–0.69). If the Hebei specimens are indeed *M. chaoi* then the ovipositor/hind tibia length would vary up to 2.4 times. Perhaps this is possible within a species but it seems unlikely.

At present, it is perhaps best to consider that *M. chaoi*, as more narrowly defined, includes specimens with a relatively short ovipositor only and either with or without a long basal seta. Much more material is needed to assess variation in these characters more confidently.

Mymaromella cyclopterus Fidalgo & De Santis
(Figs 19, 25, 31)

Palaeomymar cyclopterus Fidalgo and De Santis, 1982: 3.

Mymaromella cyclopterus Gibson et al., 2007: 100 (fig. 166, generic transfer).

Material examined.—The holotype female (Figs 19, 25, 31) and only known specimen of *M. cyclopterus*, is on a slide under one large coverslip, labelled: 1. "Galeomymar cyclopterus & A.O. Loreto, Misiones, 29.iv.1933. A.O. Typus!" 2. Palaeomymar cyclopterus Det. De Santis et Fidalgo Holotypo Museo de la Plata" 3. "3912/1".

Descriptive notes.—**Female. Body length** 409 µm (holotype).

Head. Ocelli are definitely present (Fig. 31), in contrast to what was stated in Fidalgo and De Santis (1982). The number of ommatidia cannot be counted because the eyes are mostly black (Figs 25, 31).

Antenna. Fig. 25. L(W) measurements (holotype) are: scape 56 (15); pedicel 35 (17); fl_1 15 (7), fl_2 19 (7), fl_3 21 (6), fl_4 21 (6), fl_5 24 (8), fl_6 23 (8), fl_7 27 (11), clava 96 (24). FWL 414, FWW 194, FWL(W) 2.13.

Fore wing. Fig. 19. Without a long seta on posterior margin basal to short, spine-like setae of the marginal fringe.

Mymaromella mira Girault
(Figs 22, 23, 28, 29)

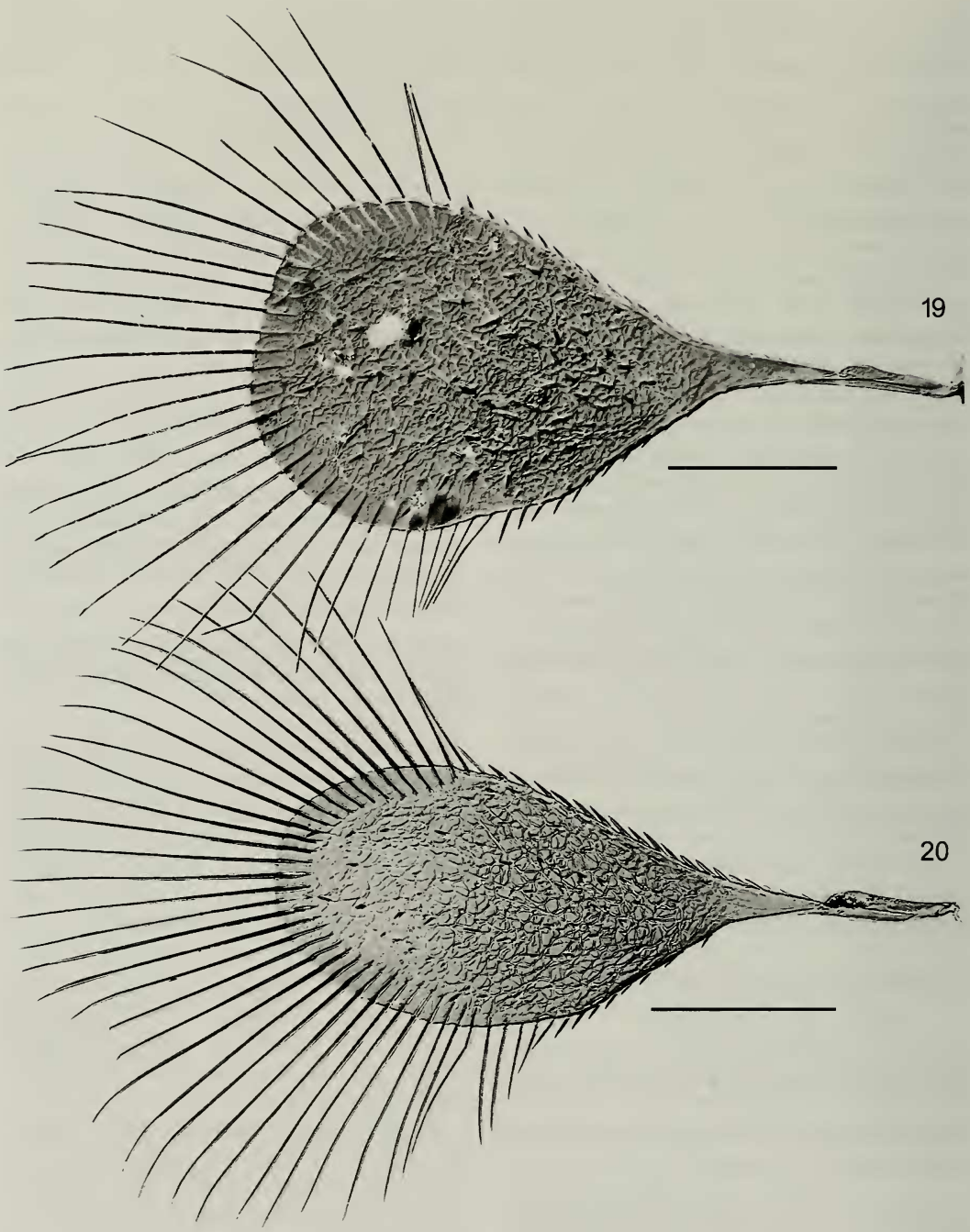
Mymaromella mira Girault, 1931: 4; Dahms, 1984: 823; Gordh et al., 1979: 283 (reprint of original description); Gibson et al., 2007: 101 and figs 13, 35, 65, 66, 93, 94, 97, 98, 162, 168 (revised status from *Palaeomymar*).

Material examined.—The holotype specimen no longer exists, but Fig. 23 is a photograph of it (Gibson et al. 2007).

Twenty-one specimens, including 5♀ and 1♂ on slides, as follows: AUSTRALIA. **ACT:** Blundells Creek, 35.22S 148.50E, ii.1987, D.H. Colless, Malaise trap (Figs. 22, 28) (2♀, ANIC); Canberra, Black Mountain, CSIRO, 1–15.ii.1999, G. Gibson, YPT (Fig. 29) (4♀, 13♂, CNC); Piccadilly Circus, 1240 m, 35.22S 148.48E, xii.1984, J. Lawrence, T. Weir, H.-L. Johnson, light intercept/window/trough trap, figured specimen in the Insects of Australia, 2nd edition (1♀, ANIC). **Victoria:** [?Ot]Otway Forest, Ormond, no date given, W.S. Anderson (1♀, USNM).

Descriptive notes.—**Female. Body length** 376 µm (n = 1, critical point dried specimen), 500–543 (n = 3, slide mounted specimens from Blundells Creek and Black Mountain). Mesosoma brown, head, appendages and petiolar segments honey yellow, gaster usually brown but in one specimen yellow.

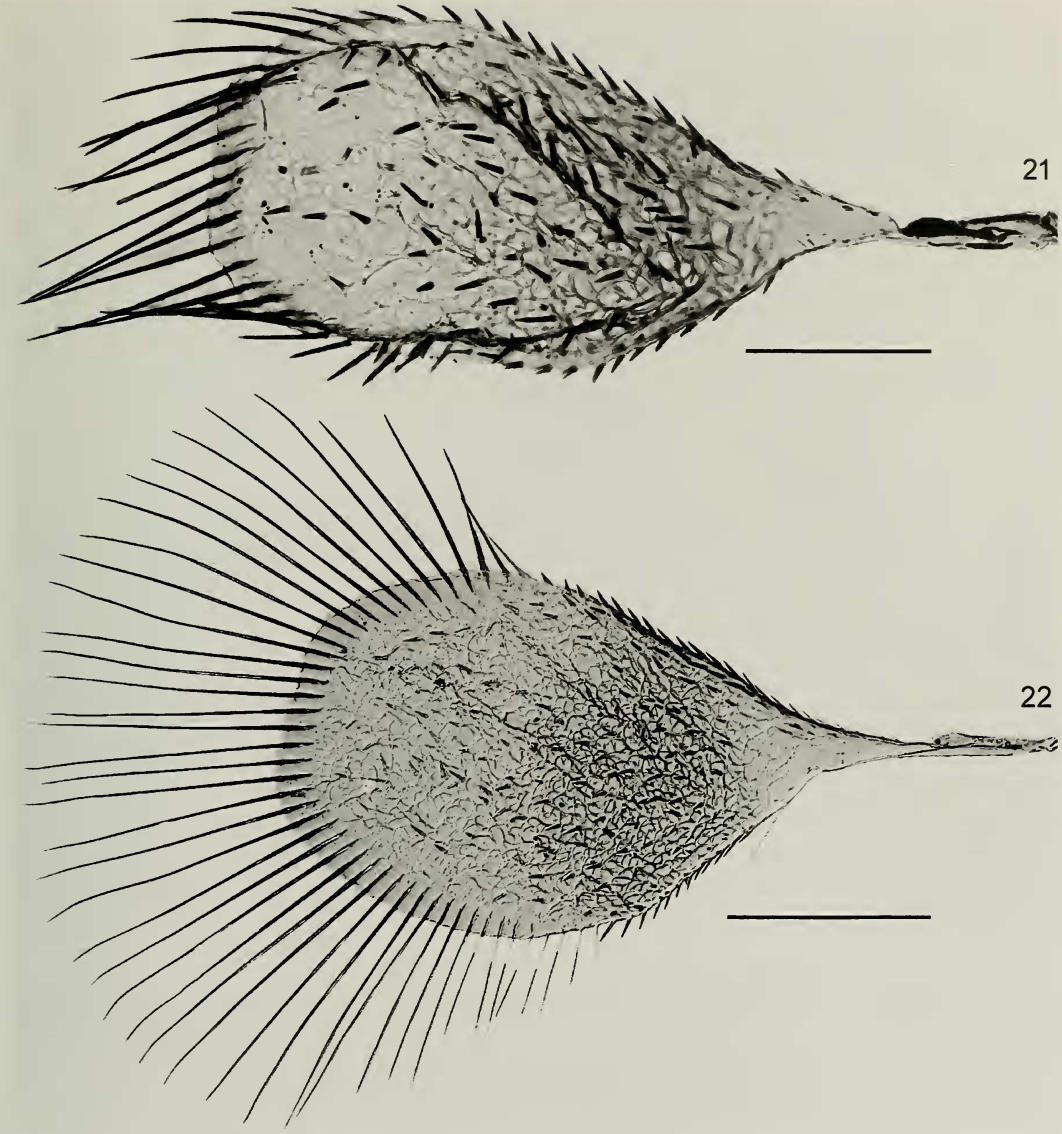
Head. Eye with at least 30 ommatidia (in Black Mountain specimens). Head width 133–142 (n = 2). Sculpture reticulate-striate



Figs 19, 20.—*Mymaromella* spp., fore wings. 19, *M. cyclopterus*, holotype; 20, *M. pala*, holotype. Scale lines = 50 μm.

(Gibson et al. 2007, figs 13, 35). Ocelli present.

Antenna. Female antenna (Fig. 28). L(W) measurements (n = 3 or, for width, 2): scape 66–68 (18); pedicel 36–38 (16–22); fl_1 18–23 (9–11), fl_2 20–24 (8–10), fl_3 24–26 (8–10), fl_4 21–23 (9–10), fl_5 26–30 (9–10), fl_6 40–44 (9–10), fl_7 33–35 (13–16), clava 106–



Figs 21, 22.—*Mymaromella* spp., fore wings. 21, *M. palella*; holotype; 22, *M. mira*. Scale lines = 50 μm.

111 (30–32), with slightly pointed apex (Fig. 29; Gibson et al. 2007, fig. 65).

Mesosoma. Mesosoma with reticulate sculpture, more distinct dorsally than laterally (Gibson et al. 2007, figs 93, 97, 98).

Fore wing. Flat, with broadly rounded apex and with hair-like basal seta (Figs 22, 23; Gibson et al. 2007, fig. 168 — seta not visible in the published image but definitely present in original photograph). Fore wing broad: FWL 508–555, FWW 222–243, FWL/W 2.15–2.29, longest marginal setae 184–190, venation length 85–86 (n = 3).

Metasoma. Petiolar segment 1 length 72–82, segment 2 length 45–47 (n = 2), both petiolar segments with irregular transverse striations and segment 1 with 2 setae at or just before mid-length (Gibson et al. 2007, figs 93, 94). Ovipositor length (including valves) 86–97 (n = 2).

Fig. 23. *Mymaromella mira*, holotype photograph.

Male. Colour as in female except gaster honey yellow. Body length 376–445 (n = 8, critical point dried specimens).

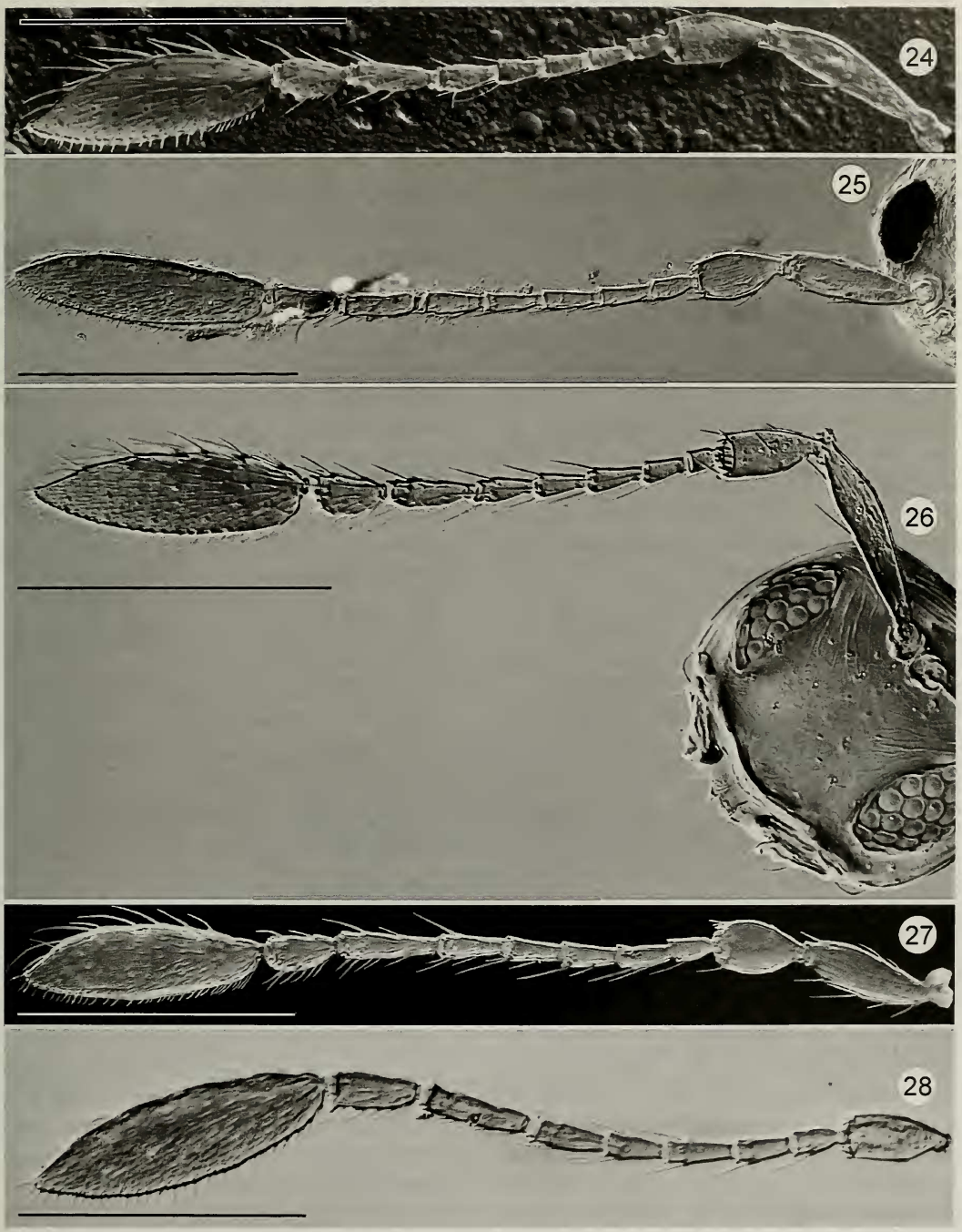
Head. Eye with about 50 ommatidia.

Antenna. Fig. 29 and Gibson et al. (2007) fig. 66. Measurements L (W) (n = 1): scape — not accurately measurable, pedicel 34 (15), fl_1 14 (8), fl_2 17 (9), fl_3 19 (9), fl_4 20 (9), fl_5 29 (9), fl_6 28 (11), fl_7 28 (13), fl_8 28 (16), fl_9 22 (17), fl_{10} 22 (15), fl_{11} 24 (14).

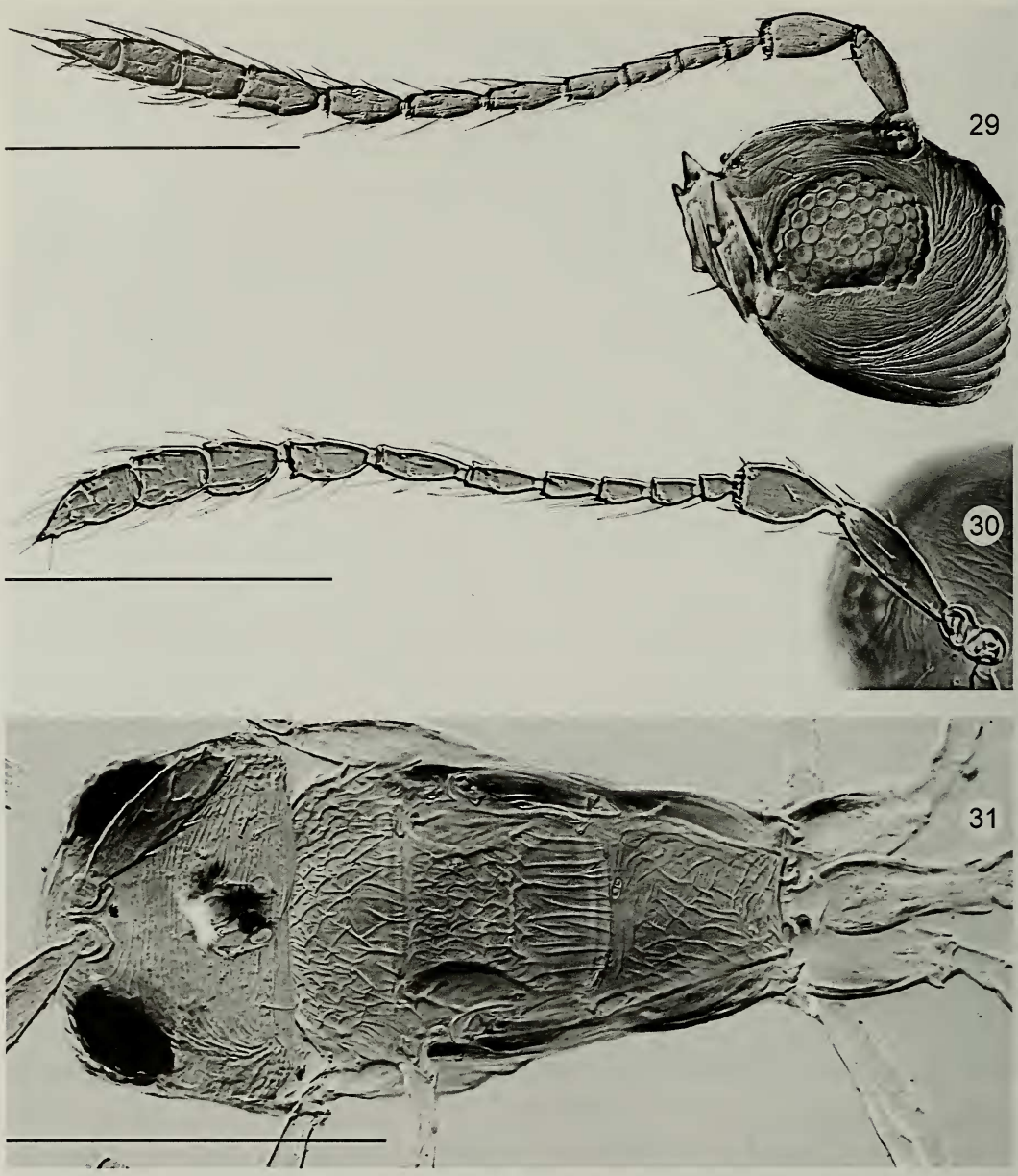
Fore wing. Fig. 23. L/W 2.63 (n = 1).

Metasoma. Genitalia (Gibson et al. 2007, fig. 162).

Variation.—Girault's (1931) description mentions six features that can be compared accurately with the slide-mounted speci-



Figs 24–28. *Mymaromella* spp., female antennae. 24, *M. chaoi*, paratype; 25, *M. cyclopterus*, holotype; 26, *M. pala* (+ head, anterior), holotype; 27, *M. palella*, holotype; 28, *M. mira*. Scale lines = 50 µm.



Figs 29–31. *Mymaromella* spp. 29, *M. mira*, male antenna + head, lateral; 30, *M. pala*, male antenna; 31, *M. cyclopterus*, head, mesosoma and first segment of gastral petiole, holotype. Scale lines = 50 µm.

mens we examined. All but one feature almost exactly matches the specimens from ACT. The one feature that does not match is that fl_6 is not nearly twice as long as fl_7 but is only 1.2–1.3 times as long on the three females we measured. We do not know how Girault measured the funicular lengths but differences in method of measurement may partially account for the discrepancy. We consider that there is a close enough match between our specimens and the original description and type photograph to be certain that the females are *M. mira*. By association, we also place the males from Black Mountain in this species although the fore wing is narrower,

with the dark band not so wide or conspicuous.

HOSTS AND BIOLOGY

The hosts and biology of Mymarommatidae are unknown. However, the information on distribution and habitat obtained from the literature and from specimens in collections provides us with circumstantial evidence for the likely host group. The evidence presented below is based on mymarommatid morphology, collection data, biogeography, habitats, and palaeontology, all of which correlate well with one order of potential hosts — the Psocoptera.

Morphology. Because Mymarommatoidea belong to the parasitic Hymenoptera, probably as the sister group of Chalcidoidea (Gibson et al. 2007), it can reasonably be assumed they are parasitoids of other insects. Their small size, rivalling that of small Mymaridae and Trichogrammatidae, and their very short ovipositors, at most about 110 µm long, suggest they parasitize the egg stage, as do members of the latter two families. We also assume that Mymarommatidae are solitary, internal parasitoids that feed on the egg contents before the host cells have begun to differentiate, thus avoiding the problem of overcoming a host immune system, which does not appear before the host larva develops. Minute wasps generally would have a harder time parasitizing the mobile stage of an insect larva or adult compared to an immobile stage (egg or pupa) because a mobile host could defend itself from attack and it would also have an immune system that would have to be countered. A disadvantage of parasitizing eggs is that the body size of an internal parasitoid is limited to that of its host egg.

What kind of eggs could be parasitized? We suggest small, thin-walled eggs from which an adult wasp could emerge in one of two ways, assuming that the parasitoid is solitary and completely fills the egg once development is complete. Mymarommatidae are unique among Hymenoptera because they have the front and back of the head joined by pleated membrane that extends between the base of each mandible across the top of the head. Either an adult mymarommatid could burst open the host egg simply by flattening the pleated membrane, thus enlarging its head (see Gibson et al. 2007, figs 13–15), through hydrostatic pressure or muscle action. Or the expanded head may not itself burst the host egg but instead provides a buttress for the exodont mandibles (another feature of Mymarommatidae — Fig. 2, 26, 29, and Gibson et al. 2007, figs 23, 25, 28, 41, 44, 49, 50) to tear a hole in the chorion through which the wasp emerges. Psocoptera have a thin egg chorion, about 1 µm thick (Seeger 1979). Because of this it may be fairly elastic and easily distorted, hence difficult for an internal parasitoid to bite through without buttressing from an expanded head. Exodont mandibles may also be more efficient than endodont mandibles in pushing an emergence hole through the soil or bark debris, silk threads or fecal material that many Psocoptera use to cover and protect their eggs (Hinton 1981), but may make it more difficult for an internal parasitoid to bite through the chorion. Consequently, a mechanism to expand the head and firmly appress the exodont mandibles to the chorion may be required.

Abundance and phenology. Mymarommatidae are usually collected singly or in small numbers. This is partly an artifact of their small size and the consequent difficulty of seeing them. Occasionally, considerable numbers (50 or more) may be collected in a short time by a particular Malaise or yellow pan trap. This suggests a mass emergence, possibly from hosts that lay clusters of eggs.

Specimens of both *Mymaromella* and *Mymaromma* Girault have been collected in the field during every month from May to September in mid latitudes of the Northern Hemisphere (Canada, USA, various European countries, Japan, Korea) and

have emerged in November from logs maintained in the lab in Michigan). In the Southern Hemisphere (Australia, New Zealand) specimens have been collected every month from October to June. In the tropics (Brazil, Côte d'Ivoire, Gabon, Hawaiian Is., Taiwan, Thailand) specimens have been collected from November to July. Presumably, a given species of mymarommatid has several generations per year and adults may be found throughout the warm season in higher latitudes and most of the year in the humid tropics.

Psocoptera lay eggs either singly or in batches, occasionally with up to 80–90 per batch, and are univoltine or multivoltine (New 1987). A given species may have several generations over many months, thus providing a fairly constant source of eggs to be parasitized. If all the eggs in a cluster were parasitized it would account for a mass emergence of a particular species of Mymarommatidae, especially if many egg clusters were so parasitized. Most Psocoptera overwinter as eggs so their eggs would serve as overwintering sites for diapausing mymarommatids.

Biogeography. Specimens of Mymarommatidae have been collected from all continents except Antarctica, and from remote oceanic islands such as Hawaii (Beardsley et al. 2000) and some subantarctic islands of New Zealand including Campbell Island, which has one species of Mymarommatidae (Valentine 1971).

Psocoptera occur worldwide including many oceanic islands such as Campbell Island, which has three species (Gressitt 1964, Gressitt and Wise 1971) mainly in moss (Gressitt 1964) among the 380 reported arthropod species. The species of Mymarommatidae on Campbell Island must be restricted to one or several of the potential arthropod hosts, possibly Psocoptera. Psocoptera are also relatively easily dispersed, sometimes (by implication) over long distances (New 1987) and evidently occur wherever mymarommatids have been collected.

Habitats. Data from the literature and from specimens assembled at the CNC for Gibson et al. (2007) indicate that most Mymarommatidae may be collected in a wide diversity of forested habitats from sea level (Bermuda) to 1050 m (Japan). Based on label data, the habitats and countries from which specimens were seen are: Peucedano-pinetum (Poland), garrigue (France), climax flood forest (Czech Republic), small meadow in old deciduous forest (Japan), secondary forest (Taiwan), mango patch (Australia), sclerophyll forest (Australia), riverine forest (Thailand), cerrado (Brazil), dense forest (New Caledonia), yellow sticky traps hung on roadside trees (Hawaii — Beardsley et al. 2000), ex ash logs from Metropolitan parks (Michigan, USA), maple and white pine litter, mixed cedar and alder litter, Berlese extract of soil from maple-hickory forest (Canada), deciduous forest litter (Canada — Clouâtre et al. 1989), *Nothofagus* forest, litter of *Stilbocarpa* in *Olearia* forest (New Zealand), and ex bracket fungus (New York, USA). The only records we have seen from outside forested habitats are: litter of *Anisotome latifolia* at upper margin of supralittoral zone, litter and peat under *Stilbocarpa polaris*, and ex *Poa tannantiana* (New Zealand: Snares, Campbell, Auckland, and Antipodes Is., from label data and from Valentine 1971), *Caprobrotus*, Munro Beach cottages (Bermuda), and an old field (USA, Maryland).

Psocoptera occur in soil and ground litter, low vegetation, on bark of tree trunks and branches, on foliage (New 1987), and in bracket fungi (Matthewman and Pielou 1971).

Palaeontology. Mymarommatoidea are known from at least 100 mya as shown by Cretaceous amber fossils from Lebanon, Canada, and Russia (Gibson et al. 2007).

Fossils of Psocoptera are known from the Jurassic and various extant families are known from 100 mya Cretaceous amber from Lebanon and India (Kukalová-Peck 1991) so they were present as potential

hosts when mymarommatids occurred in the fossil record.

Discussion.—Psocoptera are proposed as the most likely insect hosts for Mymarommatidae because their eggs are small and thin-walled, may be laid in clusters, may be present throughout the period that adult mymarommatids have been collected, and in higher latitudes are the over wintering stage. Psocoptera also occur wherever Mymarommatidae have been collected worldwide and may be abundant in a range of different habitats, including the same ones as mymarommatids. However, these lines of circumstantial evidence could fit several other groups of possible hosts that have the same distribution, habitats, fossil record and egg size as Psocoptera. Such alternative possible hosts include some Coleoptera (such as Curculionidae or Staphylinidae) and Diptera (such as various Nematocera). Other arthropod groups, notably Acari and Collembola emerged in considerable numbers from over wintered ash logs but we consider them unlikely hosts because parasitic Hymenoptera have rarely been reared from Acari and never, so far, from Collembola. Lists of species reared from bracket fungus (Matthewman and Pielou 1971) and logs of ash trees (often loaded with lichens) over wintered under laboratory conditions (this study) are fairly short. Matthewman and Pielou (1971) list 6 families and 14 species of Psocoptera among 59 families and 133 species of insects from bracket fungus in Quebec. Our ash rearings in Michigan resulted in about 30 genera of predaceous and parasitic Hymenoptera, about five genera of Diptera, about five genera of Coleoptera, and eight genera of Psocoptera including *Atropsocus atratus* (Aaron), *Blaste subquieta* (Chapman), *Blastopsocus lithinus* (Chapman) and *B. semistriatus* (Walsh), *Echmepteryx hageni* (Packard), *Loensia moesta* (Hagen), *Liposcelis* sp., *Psocus leidyi* Aaron, and *Trichadenotecnum alexanderae* Sommerman. Hymenoptera are unlikely as hosts of Mymarommatidae because they themselves are parasitic and most lay their eggs within a host and would be inaccessible for parasitism. Psocoptera therefore seem to be the most likely host group, particularly as a diversity of genera and species were reared from ash logs.

CONCLUSIONS

More species of *Mymaromella* than the five keyed above are known to us. They are numbered in Gibson et al. (2007) but we leave them undescribed until more material is collected and the respective regional faunas are studied more thoroughly. The biology of *Mymaromella* and indeed the entire family Mymarommatidae remains unknown, though we hypothesize Psocoptera as hosts based on the circumstantial evidence presented above. Whereas some other insect groups, such as certain Diptera or Coleoptera, could also be potential hosts of mymarommatids, the taxa reared from bracket fungi and ash logs seem to make these groups less likely candidates. Our hypothesis can be tested by rearing Psocoptera eggs. We suggest that the best chance of obtaining a definite rearing of any species of Mymarommatidae would be from Psocoptera eggs collected from bracket fungi, from litter and mosses collected in the subantarctic islands of New Zealand or from trunks of various ash species in north eastern North America.

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